HYDROGEN BONDING

Important: These questions will also expect you to know about van der Waals forces.

1. The boiling points of the hydrogen halides are:

	HF	HCl	HBr	HI
boiling point (K)	293	188	206	238

a) Explain why the boiling points increase from HCl through HBr to HI.

b) The boiling point of HF is far higher than it would be if it fitted the trend in the rest of the group. That is because hydrogen fluoride can form hydrogen bonds. Using HF as an example, explain what hydrogen bonds are, and how they arise.

c) Hydrogen bonding is even more effective in water, with the boiling point of water very high for the size of its molecule. Explain why water can hydrogen bond more effectively than hydrogen fluoride.

d) Ammonia, NH_3, also forms hydrogen bonds, but these have less effect on ammonia's boiling point than is the case with either water or hydrogen fluoride. Can you think of a reason why hydrogen bonding in ammonia is weaker than in HF?

2. Beryllium chloride, $BeCl_2$, is a covalent compound, which reacts with water to produce a solution containing $Be(H_2O)_4^{2+}$ and chloride ions which have water molecules more loosely attached to them.

The four water molecules attached to the beryllium ion are joined to it with co-ordinate (dative covalent) bonds where empty orbitals on the beryllium each accept a lone pair from a water molecule.

Explain how water molecules become attached to the chloride ions.

3. As well as hydrogen bonding, intermolecular forces include van der Waals dispersion forces and dipole-dipole interactions.

For each of the following, state which of these forces of attraction occur in the liquid compound. Don't be scared if you have never heard of some of these! Look at what is in the molecule, and decide which sort of intermolecular forces might be present.

You may need these electronegativity values:

H: 2.1 C: 2.5 N: 3.0 O: 3.5 F: 4.0 S: 2.5 Cl: 3.0

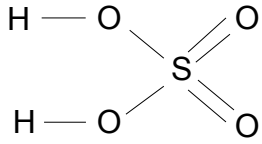
a) ethanol, CH_3CH_2OH

b) ethoxyethane, $CH_3CH_2OCH_2CH_3$

c) hydrogen sulphide, H_2S

d) ethylamine, $CH_3CH_2NH_2$

e) sulphuric acid, H_2SO_4, bonded as:



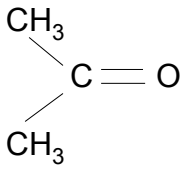
f) chloroethane, CH_3CH_2Cl

g) fluoroethane, CH_3CH_2F

h) hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$

4. A question to think about!

Propanone has the structure:



There are two lone pairs on the oxygen atom.

Trichloromethane (chloroform) has the formula $CHCl_3$. Three chlorines and a hydrogen are attached to a central carbon atom.

When propanone and trichloromethane are mixed a hydrogen bond is formed between the two molecules, although no hydrogen bonding exists in either of the pure liquids.

a) Explain why there is no hydrogen bonding in either propanone or trichloromethane when the liquids are pure.

b) Can you suggest a reason why hydrogen bonds are formed when the two liquids are mixed?